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GB 1411077 EP A1 0006085
J.H.G. Moneypenny, "Stainless Iron and Steel" pub. Chapman and Hall 1951, Vol. 1 pages 60-62 and 480-481.

(58) Field of search
C7A
F2H

(54) **Rock bolt**

(57) A rock bolt has at least a central region 18 made of a ductile austenitic stainless steel (e.g. with 12-18% Cr and 6-10% Ni) to provide yieldability. This region 18 may be of reduced diameter, and may have an extensible coating 19 whose external diameter is the same as that of the end portions 16,17. The yieldable region 18 may be welded to the end portions 16,17. It may comprise a bundle of wires 24 (Figs. 3,4). The bolt may be formed as an injection lance (Fig. 5).

FIG.1

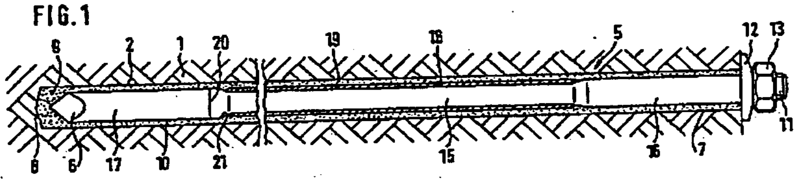


FIG. 3

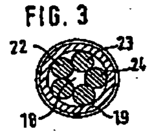
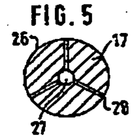


FIG. 5



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SPECIFICATION

Rock bolt

The invention relates to a rock (or roof) bolt having yieldability. Such bolts may be used for the securing of galleries and rooms in mining and tunnelling operations, and also in building site excavations and the like.

Constructional forms of rock bolts with various degrees of yieldability are already known, and are used especially in underground and tunnelling in situations where due to considerable convergence it is necessary for the bolting system used for supporting the roof or rock to be yieldable to a certain extent.

In a rock bolt known from German patent 25 11 706 the yieldability is achieved, for example, by arranging that two parts forming the rock bolt are connected to one another so as to be displaceable relatively to one another under load. A plurality of such connection zones can be provided over the length of the bolt, and they yield under load, thus allowing a braked stress-relieving movement of the rock. Apart from the considerable outlay involved in manufacturing such a bolt, insertion is also complicated, and precise setting of the braked stress-relieving movement is not possible, or is possible only with very considerable outlay.

"Gluckauf" 117 (1981) No.18, pages 1185 to 1186 describes so-called sliding bolts which comprise the bolt shank proper and a blocking part. The blocking part used is a slide tube filled with mortar, through which the bolt end provided with shearing studs has to be drawn. The force needed for cutting the mortar is equal to the response and sliding force.

Other bolts have a similar yieldability mechanism wherein the bolt shank made of cold-workable steel has to be drawn through a drawing block. Similar further proposals are given in the description. A disadvantage of all these two-part sliding bolts is the aforesaid considerable outlay involved in manufacturing the bolt shanks per se and in producing the boreholes in underground zones or in excavations and building sites. In addition, the effectiveness of such bolts depends to a not inconsiderable extent on the care with which they are put-in.

The subject of the explanation in "Gluckauf" 117 (1981) No. 17, page 1113 is the sliding bolt already described earlier herein, with a bolt shank which is provided with shearing studs which have to be drawn through a shearing lining. It has the same problems as have been described hereinbefore, and therefore is characterised by considerable manufacturing cost.

The subject of German published application 15 83 803 is a steel anchor bolt of round-section steel comprising anchoring ribs of helical form at the outside. It is provided with a specially constructed drawing ring with which the correct clamping force can be applied and maintained. In this case, therefore, it is not possible to talk of a sliding bolt, and on the contrary what is concerned is a conventional rock bolt which can in fact yield to a limited extent but which fractures prematurely when shearing stresses occur.

The rock bolts described above have the disadvantage that they consist of at least two parts, the so-called yieldability element having a greater diameter than the actual bolt shank. Therefore, it is necessary to bore multi-step boreholes or correspondingly larger-dimension boreholes into the rock, and this represents a considerable additional outlay. The manufacture of such rock bolts also involves much outlay, and also special care has to be taken when inserting the rock bolts into the boreholes in order to ensure that the bolt is fully effective.

In the case of the category-defining rock bolt known from German Utility Model 73 33 050 the yieldability or ductility is increased by a shrunk-on flexible tube so that when a fissure opens up the breaking stresses or shearing stresses which occur can easily be reduced by extension. Even in the case of a rock bolt of this kind controlled yieldability is not intended and is not attainable, especially since when shearing stresses occur in coal mining due to the opening-up of fissures the ductility of the rock bolts is over-stressed prematurely.

The invention may allow one to provide a simple-construction yieldable rock bolt which has as a whole a small external diameter and a definable ductility.

According to the invention the ductile tension member comprises stainless austenitic steel.

Such a rock bolt may have a diameter which corresponds to the rigid rock bolt, so that the borehole required for it can be made with conventional drilling machines without great outlay. Since the boreholes are of a single stage throughout, the cost of producing them is further reduced and less time is taken to produce them. This has the advantage that even in the case of brittle rock it is possible to obviate any filling of the borehole by immediately inserting the bolt shank. With the use of the tension member made from austenitic steel the necessary high degree of adjustability can be achieved very quickly, since it hardens additionally when deformation occurs, and the bolt shank overall has available a considerable ductility, with as a whole a shallow extension characteristic. Thus, the characteristic approximates to the optimum characteristic of yieldable rock bolts, and the displacement amount is adaptable to circumstances by arrangement and construction of the material.

It has been found that a steel alloy with nickel and chromium contents has proved advantageous as the austenitic material for the production of the bolt shank, and it is expedient to use as the material a steel alloy containing 12 to 18 % chromium and 6 to 10 % preferably 6 to 8 % nickel. Such a steel alloy results in cold work hardening when tensile stress occurs and plastic deformation results from such stress, since because of the deformation a more or less considerable transformation takes place in the martensite. The cold work hardening can be controlled through the nickel content, so that on the other hand the action of the rock bolt is adaptable to circumstances.

To ensure satisfactory effectiveness in the yieldable rock bolt it is advantageous if the tension

member has a specific yieldability zone formed of a shank portion of smaller diameter. In such a case the necessary yieldability is achieved in this yieldability zone, whereas the two ends are connected to the rock, so that the middle portion can be subjected to tensile stress appropriately. By suitable choice of the fastened end regions of the tension member the yieldability zone can be situated exactly in the middle of the tension member, or shifted more into the vicinity of the borehole mouth or the bottom of the borehole, in accordance with the requirements of what have been found to be the relevant circumstances in each case.

Since the fastened ends do not have to contribute anything to the yieldability of the rock bolt, it may be advantageous to make the middle portion of the tension member with the yieldability zone from austenitic steel and the ends from normal steel material. Thus less costly material can be used for these regions without thereby negatively influencing the effectiveness of the rock bolt overall.

The rock bolt can also be clamped in the borehole with the use of an anchor plate associated with the mouth of the borehole, and a nut. Then it is advantageous to make the tension member end projecting from the borehole from normal steel material and connect it preferably by welding to the middle portion. This allows advantageous application of the anchor plate and nut and also of the clamping forces. Since the material in this region does not elongate, or undergoes only slight elongation, it is possible to shift the nut subsequently on the screwthread of the lower end when the need arises, which would include the aim of re-tightening.

The sliding of the tension member in the borehole, or especially of the middle portion with its yieldability zone, is not impeded and blocked by an adhesive substance if, as is known per se, the yieldability zone forming the middle portion of the tension member is provided as a whole with an extensible coating. For example a shrunk-on flexible tube such as is known in principle from German Utility Model 75 33 050 may be used as the extensible coating. This ensures that the adhesive substance cannot penetrate to the outer surface of the bolt shank, or the middle portion, even under the pressure which sometimes occurs in a borehole.

According to a further form of embodiment the yieldability zone can be varied by giving the tension member a middle portion comprising a bunch of rods or wires. Somewhat similar bunches, or wire-assembly bolts, are known basically from "Excavation, construction engineering, road construction" 8/1980, pages 674 to 677, although they are used there like conventional one-piece rock bolts. In contrast thereto, in the present embodiment all the rods consist of austenitic stainless steel and they are advantageously encased individually or as a group in an extensible coating or a shrunk-on flexible sleeve or tube. By appropriate choice of the diameter, number and arrangement of the rods the yieldability of the rock bolt can be additionally varied here.

Depending on where the rock bolt is being used, it is advantageous to secure the tension member adhesively in the bottom of the borehole and then clamp it with the use of the anchor plate and the nut, or to connect both end regions of the tension member effectively by means of the adhesive substance to the rock. In one advantageous type of embodiment, the middle part can be left free of adhesive substance, and the tension member is contructed as an injecting lance analogously to that shown in German laid-open specification 25 56 493. In using such a lance the end inserted into the borehole (and optionally the opposite end as well) is to be fastened in the borehole or secured adhesively in controlled manner. By controlled injection either by means of a bore and appropriate ducts in the tension member, or alternatively by separate thin injecting lances, the tension member can be connected to the rock, or secured, in controlled manner, at the places where this would be advantageous for the effectiveness of the complete rock bolt, even where lengths are considerable.

To obviate difficulties in inserting the tension member into the borehole, for example through jamming or sticking on projections or cracks, in one type of embodiment the diameter of the middle portion together with the applied coating corresponds to the diameter of the ends. Thus a shank is provided which is uniform throughout and which as mentioned can be introduced safely and without a great amount of work into the borehole. It is possible to weld the austenitic middle portion to the normal-steel ends without detrimental effects if the weld is arranged at a spacing from the transition to the specific yieldability zone in the region of the shank portion of larger diameter.

Embodiments of the invention provide a yeildable rock bolt which is simple to produce and use, which has an approximately optimum operating characteristic with high level of adjustablility, and which is also non-rusting because of the chromium content and therefore may also be used as a ground anchor. Because it is non-rusting it also retains full effectiveness after long service life, and by selecting the alloy, the form and the association of the zone it can be suited to particular circumstances. Besides an approximately optimum adjusting ability the rock bolt may have available great ductility with a shallow ductility or extension characteristic, so that it fully meets the requirements expected of sliding bolts.

The invention is explained in detail in the following description with reference to the associated drawings which show preferred examples of embodiment with the details and components required. In these drawings:

Figure 1 shows a rock bolt in use,

Figure 2 shows a section through the rock bolt in the region of the yieldability zone,

Figure 3 shows a section through the rock bolt in the region of the yieldability zone in a case where a plurality of rods form the middle portion,

Figure 4 shows a section as in Figure 3 with the coating differently arranged, and

Figure 5 shows a section through a rock bolt which is arranged to act as an injecting lance at the same time.

Figure 1 shows a borehole 2 which has been

formed in the rock 1 and into which a yieldably constructed rock bolt 5 has been introduced. The tip 6 of this rock bolt 5 is taken close to the borehole bottom 8, and fastened there by means of an adhesive substance 9. The adhesive substance, which together with the bolt 5 substantially fills the borehole, also effectively connects to the rock 1 that end of the rcok bolt which is associated with the borehole mouth 7. The entire tension member 10, whose end projecting out of the borehole mouth 7 has a screwthread 11, can be clamped in the borehole 2 with the use of the anchor plate 12 and the nut 13, or may be adhesively fixed in position at both ends.

The rock bolt 5 according to Figure 1 is given the necessary yieldability by a centrally arranged yieldability zone 15. Whereas the two ends 16, 17 of the tension member 10 are connected to the rock by means of the adhesive substance, the middle portion 18 is provided with a coating 19 so that the adhesive substance 9 should not prevent displacement of the middle portion 18, which is made from austenitic material. In the form of embodiment shown in Figure 1, the ends 16, 17 are of normal steel connected by welding to the middle portion 18 made of an austenitic steel alloy. The welds are designated as 20.

The rock bolt 5 shown in Figure 1 is broken away in the region of the yieldability zone 15, or the middle portion 18, and a sectional view therethrough is shown in Figure 2. The middle portion 18 of the tension member 10 is covered, as illustrated, with a coating 19 consisting for example of a shrunk-on flexible tube. 26 designates the periphery of the end 17 of the tension member 10. Figures 3 and 4 show a form of embodiment wherein the middle portion 18 consists of a bunch of rods 22, 23, 24. The rods 22 to 24 are made of the aforesaid austenitic steel alloy, and they are surrounded with a coating 19. This coating 19 can be formed as a covering wrapping the bunch as shown in Figure 3 or as an outer skin in which they are bonded.

Figure 5, finally, shows a section through a tension member in the region of an end 16 or 17, and here the tension member is constructed as an injecting lance and is provided accordingly with a through bore 27. In the region of the ends 16, 17, or of only one of the two ends, there are provided ducts 28 through which the grouting or the adhesive material can enter the annular space provided in each case, so as thus to secure the tension member 10 adhesively and connect it to the rock 1. It is possible to use an advantageously small borehole diameter, which has the result of reducing costs but adds to the expense of producing the tension member 10.

The welding of the austenitic material to the normal steel can be carried out safely since as shown in Figure 1 the welds are situated in the region of the normal diameter of the tension member. Thus it is guaranteed at the same time that the welding operation cannot modify the structure in the region of the specific yieldability zone.

The coating 19 may be conformable. It may be elastic.

CLAIMS

1. Rock bolt comprising a tension member made at least in part of a ductile stainless austenitic steel.

2. Rock bolt according to claim 1 wherein the tension member is adapted to be secured to a borehole at inner and outer end regions.

3. Rock bolt according to claim 1 or 2 including an anchor plate adapted to be pressed against rock or a boundary wall in which the bolt is to be set.

4. Rock bolt according to any preceding claim wherein said steel alloy includes nickel and chromium.

5. Rock bolt according to claim 4 wherein the tension member is made at least in part of a steel alloy which contains 12 to 18% chromium and 6 to 10% nickel; the rest of the alloy being preferably iron and unavoidable impurities.

6. Rock bolt according to any preceding claim wherein the tension member has a zone of yieldability, consisting of a shank portion of smaller diameter.

7. Rock bolt according to any preceding claim wherein the tension member has a middle portion of said austenitic steel material to provide a zone of yieldability.

8. Rock bolt according to claim 7 wherein at least one of the end portions of the tension member is made of a different steel material from said middle portion.

9. Rock bolt according to claim 8 wherein only that end portion of the tension member which in use is intended to project out of the borehole is made of normal steel material, which differs from the middle material.

10. Rock bolt according to claim 8 or 9 wherein at least one said end portion is connected to the middle portion by welding.

11. Rock bolt according to claim 10 wherein the or each weld is spaced from a transition to the yieldability zone.

12. Rock bolt according to any of claims 7 to 11 wherein the yieldability zone has an extensible coating.

13. Rock bolt according to claim 12 wherein the diameter of the middle portion including the coating corresponds to the diameter of the end portions.

14. Rock bolt according to any of claims 7 to 13 wherein the tension member's middle portion consists of a bunch of rods or wires.

15. Rock bolt according to any preceding claim wherein the tension member is constructed as an injecting lance for use in securing one or both end regions of the bolt to a borehole.

16. Rock bolt substantially as described herein with reference to and/or as illustrated in any of the accompanying drawings.

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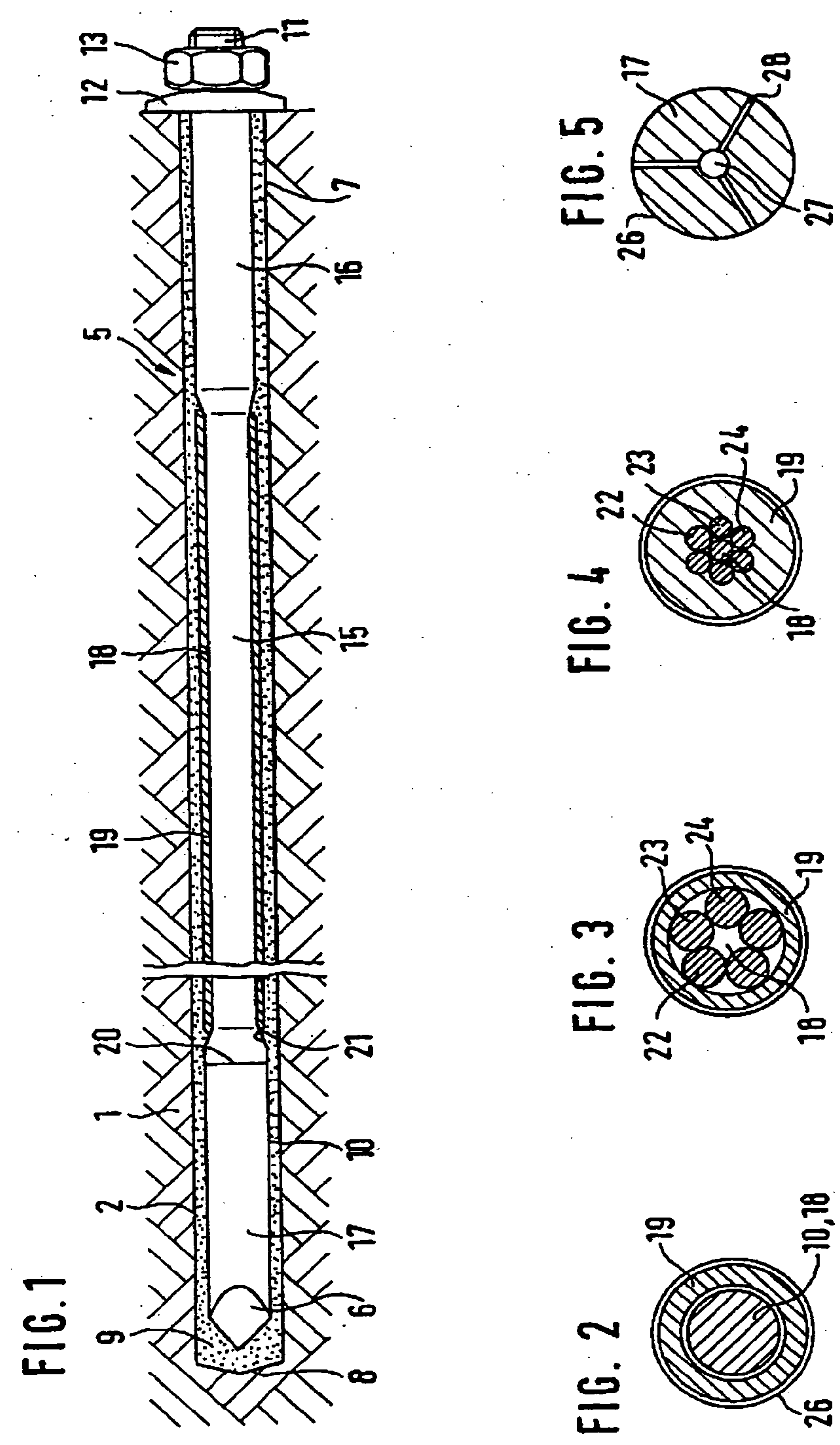

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5